International Journal of Ecology and Environmental Sciences
www.ecologyjournal.in
Online ISSN: 2664-7133; Print ISSN: 2664-7125; Impact Factor: RJIF 5.28
Received: 25-07-2020; Accepted: 10-08-2020; ; Published: 26-08-2020
Volume 2; Issue 3; 2020; Page No. 178-190

Shoreline change assessment & future projections for a coastal tourism belt of West Bengal, India

Aditi Bose[1], Suchandra Bardhan[2], Kaberi Samanta[3]
[1] School of Oceanographic Studies, Jadavpur University, Kolkata, West Bengal, India
[2] Department of Architecture Jadavpur University, Kolkata, West Bengal, India

Abstract
Coastal Tourism is a widely popular and commercially viable form of tourism around the world. However, it is also vulnerable to the active natural forces affecting the coast, for which management of coastal systems based on understanding of shoreline changes and their future projection plays a very important role. In this paper we have analysed the shoreline change dynamics of the well-known *Digha--Mandarmani* coastal tourism belt of West Bengal, India using Remote Sensing & GIS methods and also project the future shoreline profiles of 2050 with potential impact on the tourism establishments of the area. The *Digha* coastal zone is facing serious environmental challenges due to coastal erosion and unregulated human interventions. This paper presents a lustrum shoreline study along the *Digha* coast over the last 15 years using the application of multi-temporal high resolution Satellite datasets. The analysis of past and present changes of shoreline along the coast in *Digha* and *Mandarmani* shows significant variations in the form of erosion and accretion with negative consequences to the tourism infrastructure in certain cases. This study also predicts the future changes of *Digha--Mandarmani* shoreline assuming business as usual scenario. The GIS maps prepared in course of this research are expected to contribute to the shoreline management measures for sustainable tourism development in this very significant tourism belt of the state.

Keywords: shoreline, coastal, future projection, tourism, sustainability

Introduction
Digha and Mandarmani are two popular seaside tourist destinations facing the Bay of Bengal in the State of West Bengal, India. While Digha, with its old and new tourism sprawl is in its matured state of tourism activity, Mandarmani is a fairly new addition in the tourism map of the State that has grown largely driven by market forces. However, both areas fall within an active coastal belt where shoreline has been reported to be changing with erosion and/or accretion) due to littoral transport (i.e. movement of eroded sand by waves in near shore zone) (Mukhopadhyay *et al*, 2017) [12]. Natural processes like wave currents, near-shore circulation, sediment characteristics, beach forms etc. and human interventions such as dykes and dams, dredging, sand mining, water extraction, tourism etc. are responsible for such unintended changes (ibid). In the context of coastal vulnerability, accreting coastlines are considered less vulnerable, as they result in the addition of land areas by moving towards the ocean. On the other hand, eroding coastlines are considered highly vulnerable as they result in the loss of land by moving towards the beach and also result in loss of natural as well as man-made resources associated with it. Thus healthy coastline and beaches are essential for the business and also to protect the critical habitats of many plants and animal species from any kind of coastal hazard and also maintain the quality of life (Kankara etal, 2013,). It is important to monitor and predict shoreline changes over a long timescale in order to identify the specific causes of erosion and accretion of coastline in a particular area; and the anthropogenic and human intervention related impacts, to evaluate geomorphic & ecological changes and accordingly plan for protection measures (Misra and Balaji, 2015,) [13]. In order to accomplish this, coastal zone requires an application of geoinformatics along with site specific research, due to the complexities associated with coast even at the regional level (ibid).

Though Traditional ground surveying techniques are relatively more accurate, but it is highly time consuming and impossible to accomplish for a large coastal belt (Selvan, Kankara and Rajan, 2014,) [11, 17]. On the other hand Remote Sensing (RS) and Geographical Information System (GIS) based geo informatics is accurate, cost effective, less time consuming and can cover a large coastal belt where the RS provides a source of spatial and multi-temporal data, and the GIS is useful for mapping (ibid). Thus, these tools provide an opportunity to develop information database and support decision making activities for coastal zone applications (ibid). With this perspective, the current study aims to analyse the shoreline changes along *Digha--Mandarmani* coast of West Bengal using RS & GIS as a tool to demarcate the erosion and accretion zones, to project the future shoreline position and to understand the vulnerability of the tourism establishments of this region to such changes. The overall objective of this study is to produce shoreline change maps that can be used by coastal authorities to make an effective coastal zone management plan for this region.

2. Study Area
The coastal belt of Midnapore district represents 27% of total coastal tract of West Bengal (60km) extending along the west bank of Hooghly estuary. On the west from Orissa border via Udaipur, Digha, Tajpur, Shankarpur, then curving around Mandarmani, Dadanpatrabar, Khejuri and Haldia on the east the shoreline extends further north-east up to Tamluk (Baitalik and

Majumdar, 2015,). The study area from Udaipur Beach to Mandarmani Beach is stretched between 21°36”39.36’ N latitude & 87°29”02.30’E longitude to 21°39”51.57’N latitude & 87°42”21.90’E longitude (Plate 1). Digha & Mandarmani falls under Contai division of East-Medinipur district (Mandal, Dandapath and Bhushan, 2013, p. 46). It has a MSL of 6 mts (20 ft.). The present analysis is concerned with the coastal width of 3 KM from the LTL, where major tourism establishments are located and which bears the brunt of major coastal hazards like erosion/accretion, cyclone and surges.

Fig 1: Geographical Position of the Study Area (from Google Earth Images

3. Materials and Methods

3.1. Preparation of Data (Satellite Image)

Satellite images of the years 2000, 2005, 2010, 2015, and 2019 from Earth Explorer were downloaded. Through layer stack and subset the images were made usable for further study.

3.2. Digitization of Shoreline

The coastline from Udaipur to Mandarmani was digitized from Google Earth to accurately identify the coastline considered for study. The coastlines for the years 2000, 2005, 2010, 2015 of Udaipur to Mandarmani area were digitized from multitemporal satellite data of winter months of similar tidal phase using the tonal and colour differences between the land and the sea.

3.3. Analysis of Shoreline Change

All such 4 digitized coastlines of 2000, 2005, 2010, and 2015 were overlaid and analysed in high spatial resolution to identify and compare the erosion - accretion zones and to produce maps of shoreline changes for all the selected locations in a GIS platform.

3.4. Estimation of Shoreline Changes Rates

In the present study the simple Fishnet application of Arc GIS extension was used. Altogether 72 transects were drawn to accurately estimate erosion and accretion rate over four coastlines of selected years and coastlines were projected on it. Finally the erosion and accretion rates were measured in Arc GIS platform for the time window of 2000-2015 for a longer time frame to determine the average retreat or advancement of shoreline.

3.5. Future Prediction of Shoreline Movement

With the help of average erosion and accretion rate from 2000 to 2015, change was estimated along each transact and linearly projected for 2050 along the same transact.

The projected shoreline of 2050 thus created, along with other shorelines of selected years were overlaid on a satellite image of the area for the year 2019.

And to compare the impact of erosion – accretion on the coast in future predicted GIS maps of 2050 for all the ten spots were generated

4. Shoreline Delineation and Identification

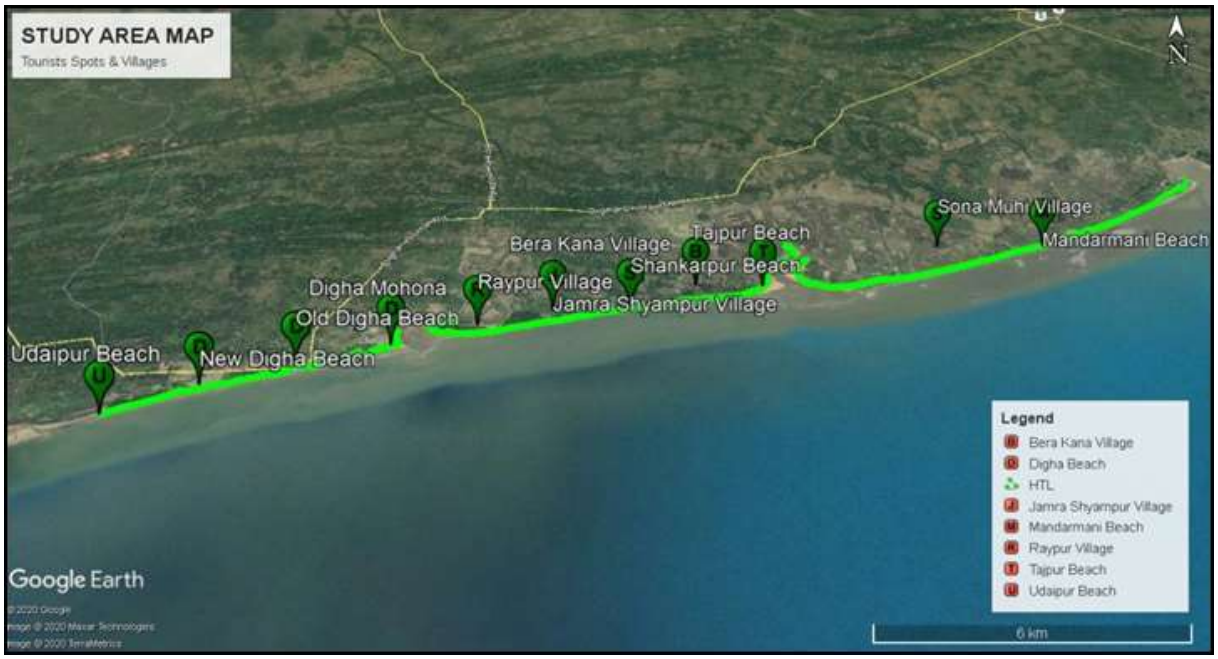

Fig 2: Total Mapped Shoreline of the Study Area Study Area with Tourist Spots &Villages (from Google Earth Images)

The long shoreline from Udaipur to Mandarmani was divided in to ten segments for focussed analysis according to the tourist activities. These were Udaipur, New Digha, Old Digha, Digha Mohona, Raypur, Jamra Shyampur, Shankarpur, Bera Kana, Tajpur, Sona Muhi and Mandarmani (Plate 2). Furthermore all the ten segments were further subdivided into seventeen smaller segments for accurate analysis.

5. Result and Discussion

5.1. Identification of Erosion and Accretion Zones

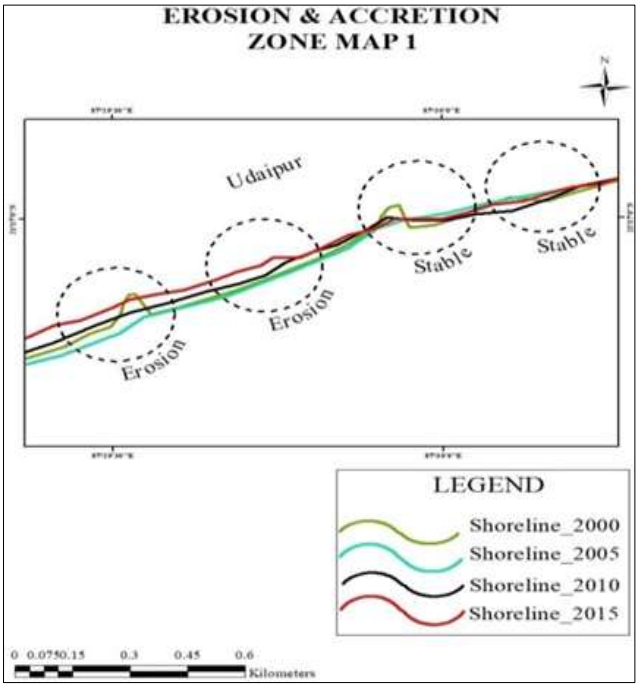

Fig 3: Shoreline Overlay of Consecutive *Year in Udaipur*

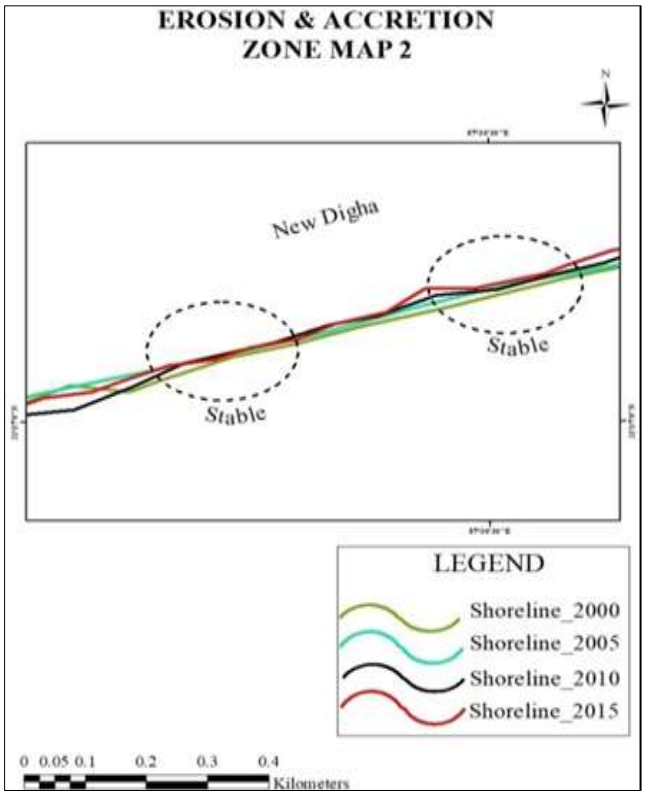

Fig 4: Shoreline Overlay of Consecutive Year in New Digha

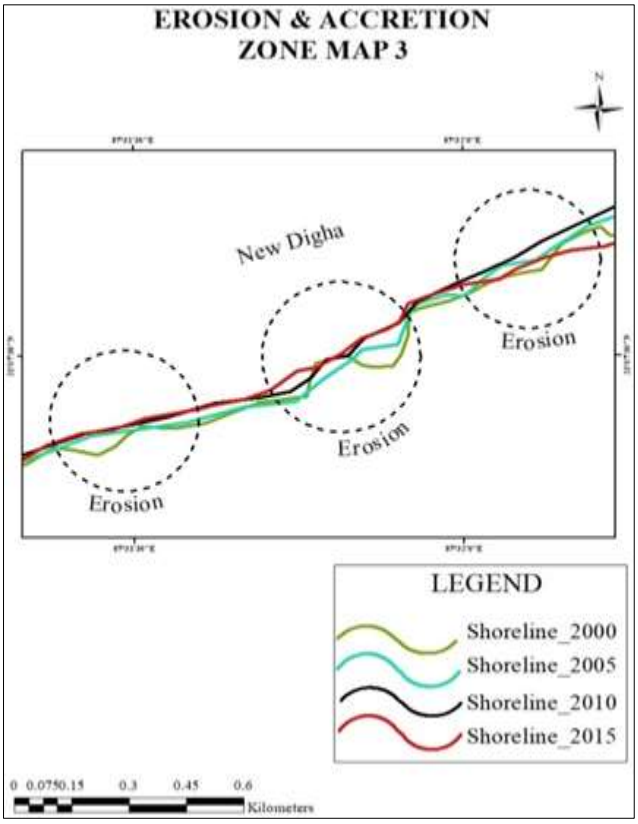

Fig 5: Shoreline Overlay of Consecutive Year in New Digha

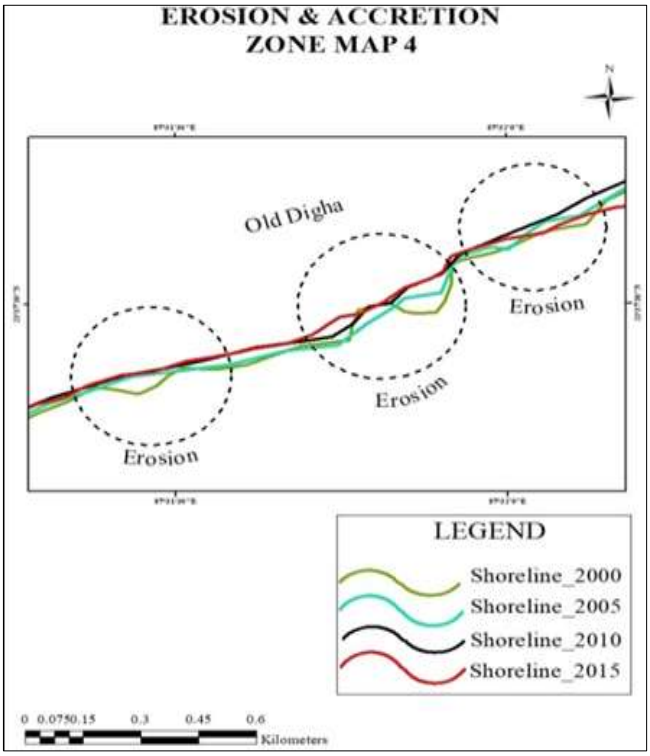

Fig 6: Shoreline Overlay of Consecutive Year in Digha Mohona

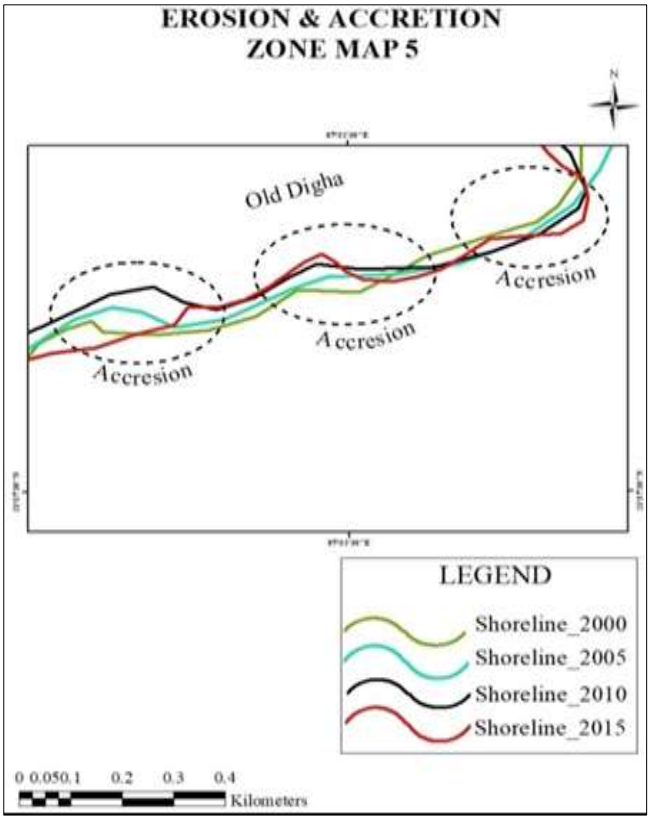

Fig 7: Shoreline Overlay of Consecutive Year in Digha Mohona

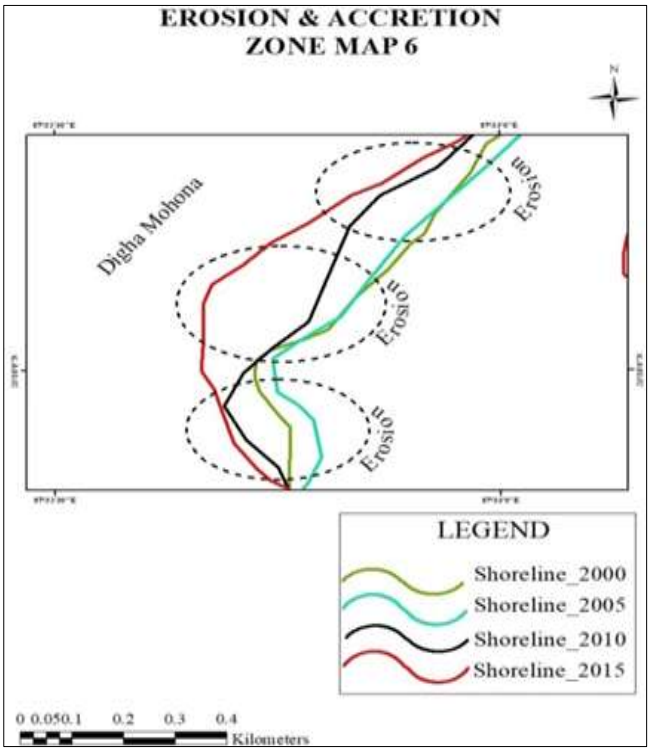

Fig 8: Shoreline Overlay of Consecutive Year in Raypur

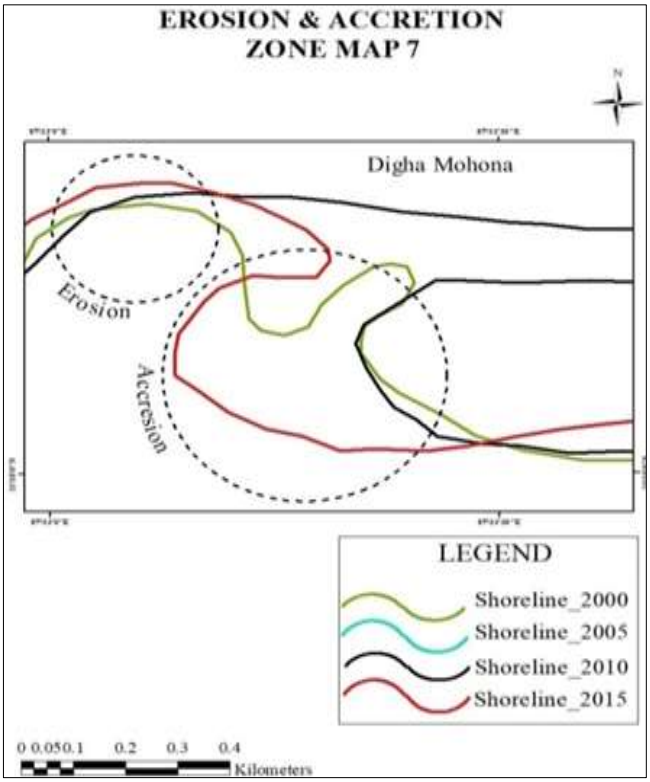

Fig 9: Shoreline Overlay of Consecutive Year in Jamra Shyampur

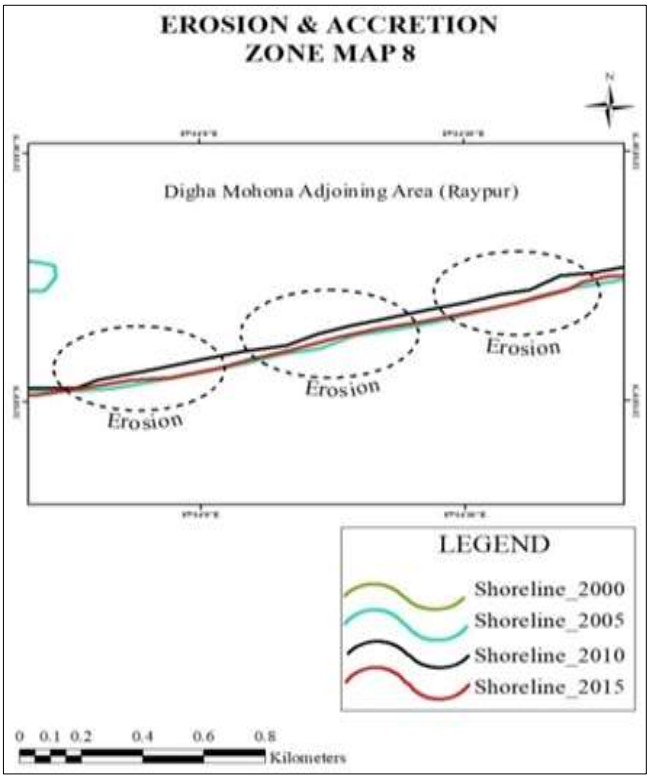

Fig 10: Shoreline Overlay of Consecutive Year in Shankarpur

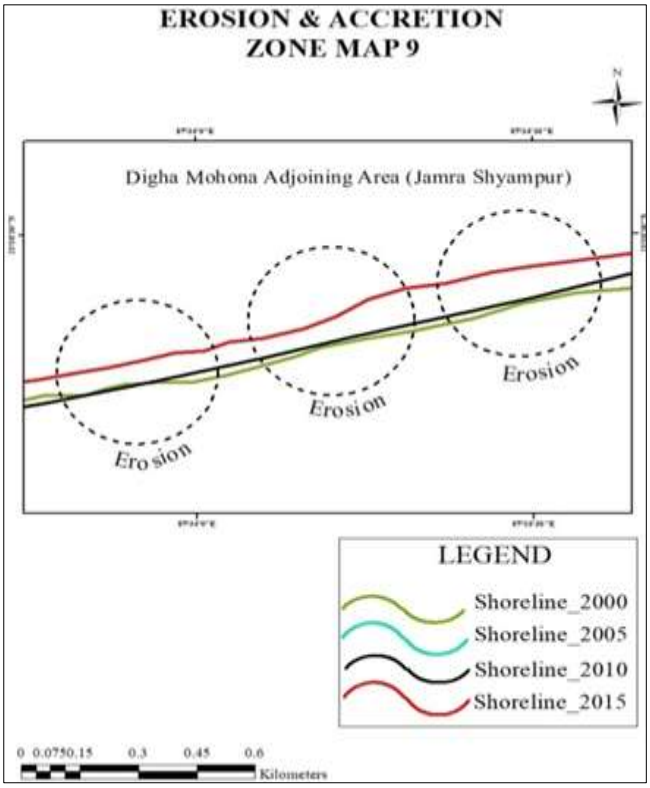

Fig 11: Shoreline Overlay of Consecutive Year in Shankarpur

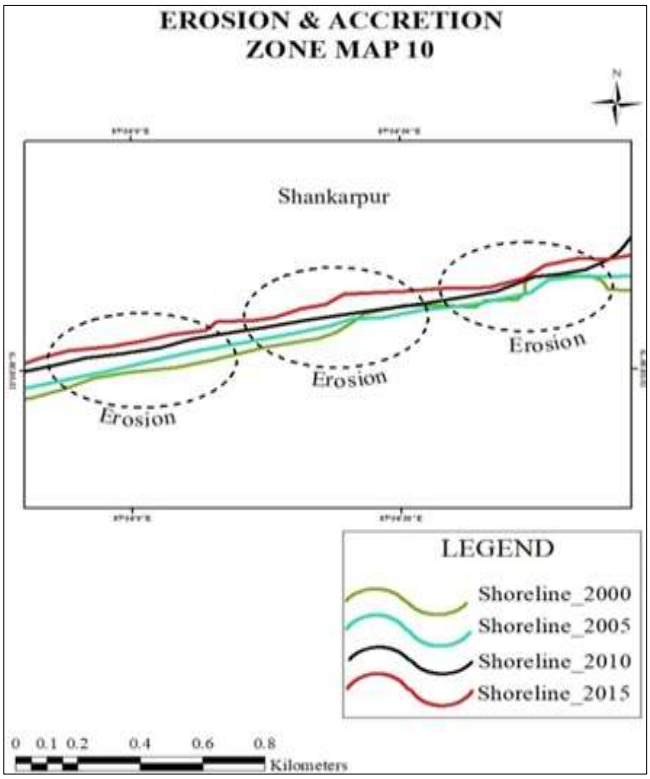

Fig 12: Shoreline Overlay of Consecutive Year in Tajpur

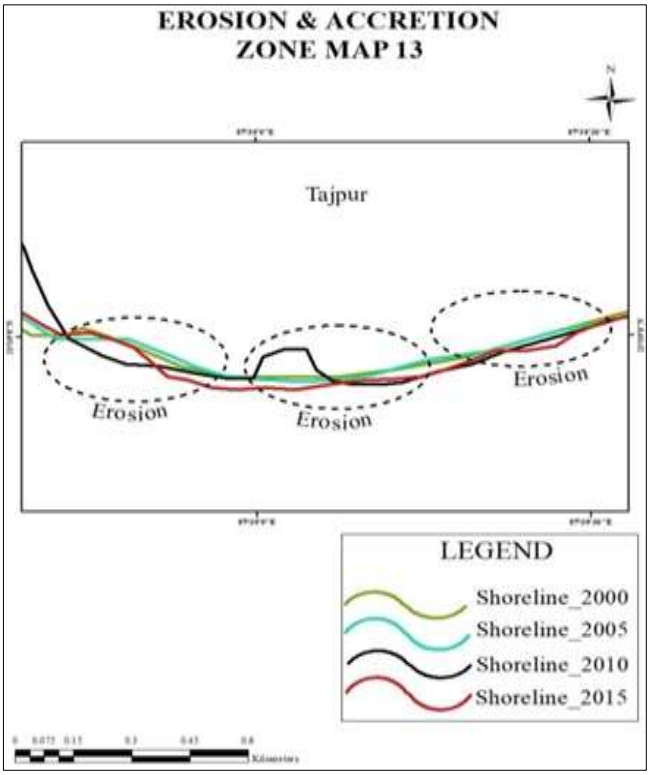

Fig 13: Shoreline Overlay of Consecutive *Year in Tajpur*

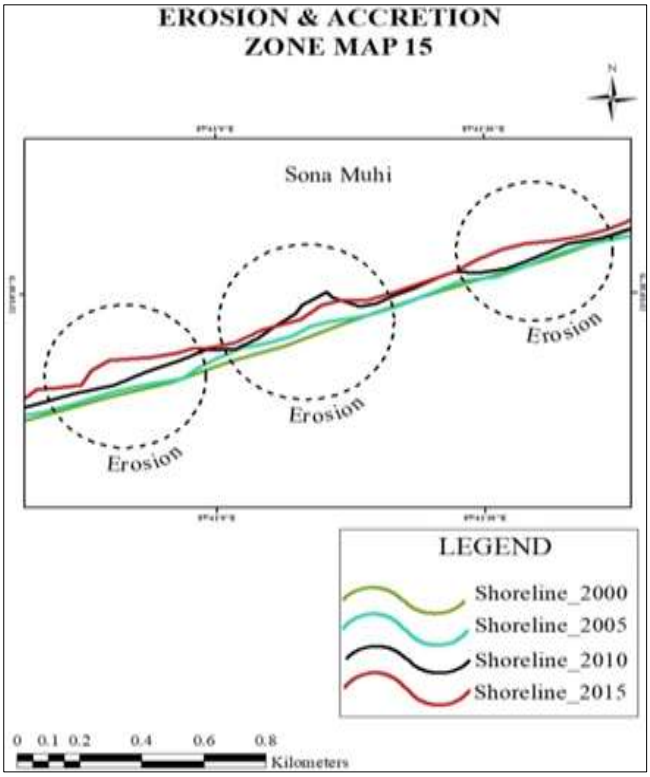

Fig 15: Shoreline Overlay of Consecutive Year in on Sona Muhi

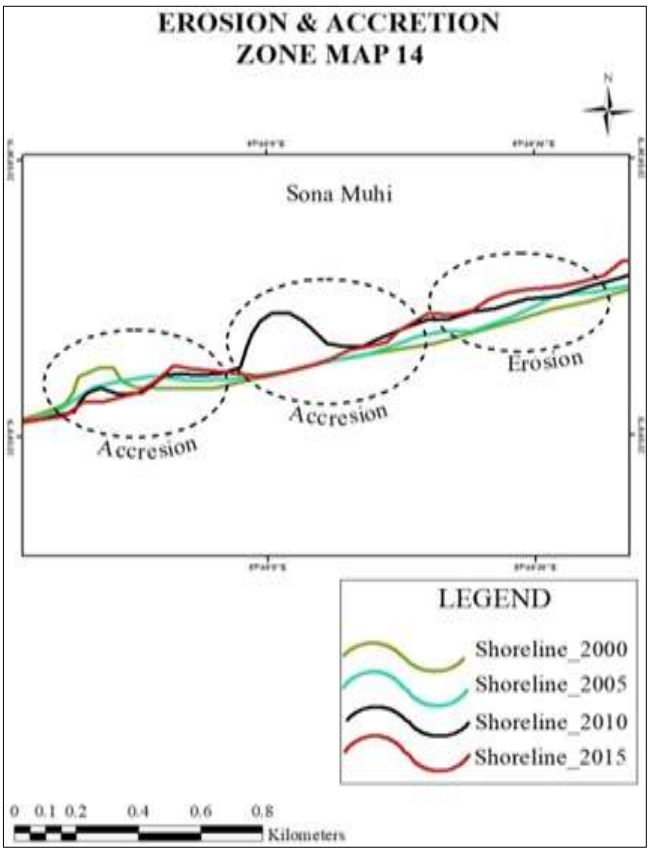

Fig 14: Shoreline Overlay of Consecutive Year in Sona Muhi

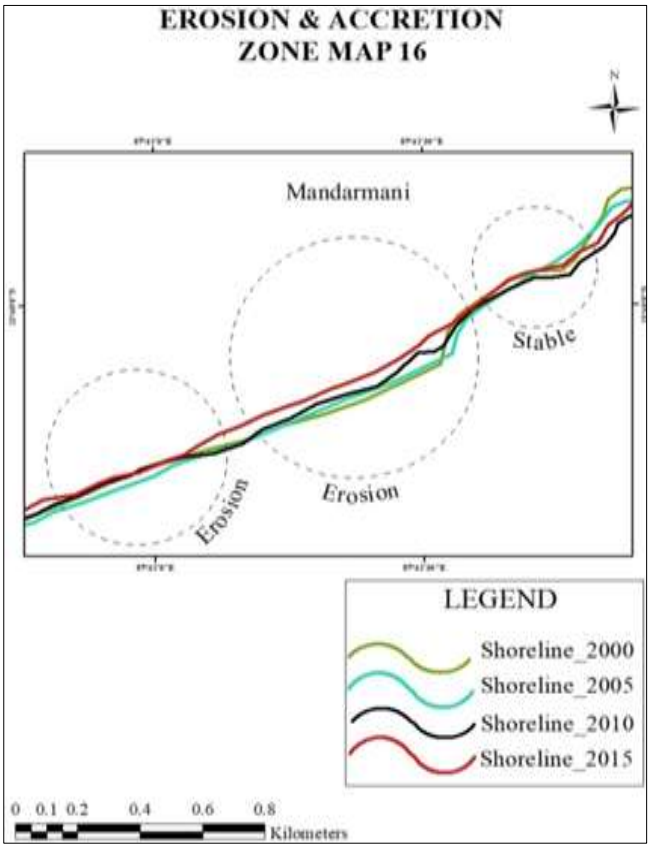

Fig 16: Shoreline Overlay of Consecutive Year in Mandarmani

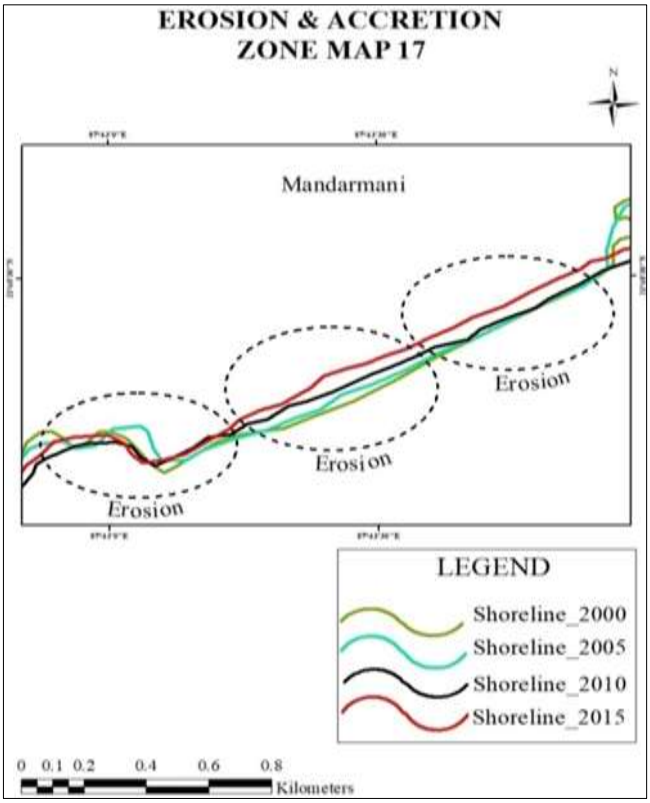

Fig 17: Shoreline Overlay of Consecutive Years in Mandarmani

The results obtained are presented in the figures 5-1 to 5-17 and discussed hereafter. The shoreline change (retreating or advancing) was identified for all the ten important locations of already developed and developing tourism establishments. From 2000 to 2005 all the locations between Udaipur to Mandarmani were observed to have undergone medium scale erosion. Limited accretion was observed only at, Digha Mohona and Sona Muhi. During the period 2005 to 2010, the entire coastal stretch from Udaipur to Mandarmani suffered severe erosion.. During 2010-2015, however, there was a change in the mode and tempo of the erosion and accretion. While the Udaipur shoreline retreated in 70% of the area but accreted in 30% of the area. Along the New Digha area erosion and accretion appeared to be equally balanced. In the Old Digha coastal belt, erosion dominated over accretion. But in Digha Mohona area, 80% of the coastal stretch was found to be under severe erosion while minor accretion was observed along remaining 20% area. The coastline along the h Raypur and Jamra Shyampur Villages showed significant landward retreat. The costal stretch around Shankarpur showed dominant erosion over 80% of the area. The severity of erosion increased further at Tajpur, the newly emerging tourist destination. Along the Mandarmani coast, the already developed tourism establishments were found to be under severe threat as 90% of the coastline was found to be under erosion.

5.2. Long Term Shoreline Movement Estimation

The erosion and accretion rate from 2000 to 2015 measured along the selected transacts of the tourist locations from the West to East were given in the Table 1 with qualitative and quantitative estimation

Table 1: Long Term Erosion and Accretion Rate Estimation of shoreline

Long Term Shoreline Movement Rate Estimation			
Tourist Spot	**Transect No**	**2000-2015**	
		Accretion mts / year	**Erosion mts/ year**
Udaipur	1-4	Very Low 1.07	High 8.32
New Digha	5-10	Nil 0	Moderate 9.43
Old Digha	11-15	Very Low 0.25	Moderate 10.25
Digha Mohona	16-20	High 15.41	Very High 25.78
Shankarpur	30-35	Nil 0	Very High 40.82
Tajpur	39-43	Medium 11.56	Moderate 7.6
Mandarmani	52-60	Nil 0	Very High 29.78

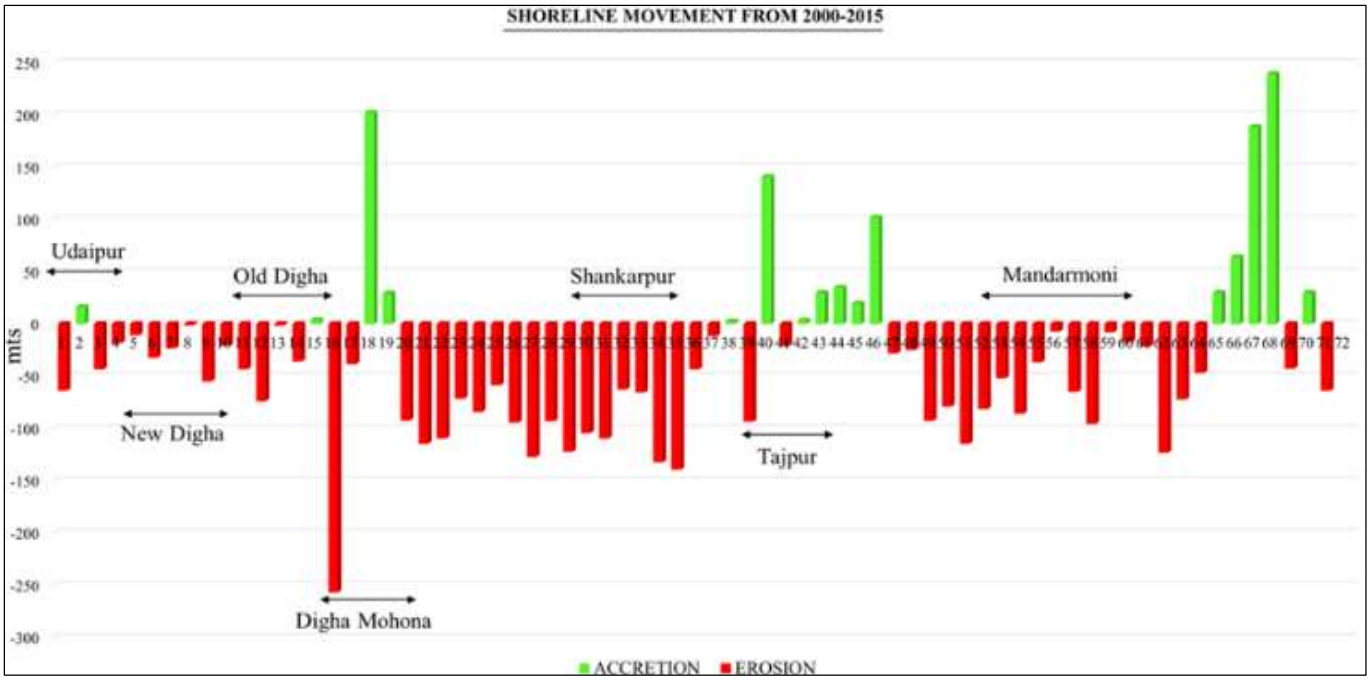

Fig 18: Long Term Erosion & Accretion Rate Estimation of shoreline

The long term analysis of shoreline change excludes short lived impacts of storms and tidal surges but indicates impacts of littoral drifts, sediment supply and sea level change. Along the coast under study, impacts of a number of manmade structures like sea walls and groins, particularly at Old Digha and Digha Mohona area could produce some anomalous pattern by altering the sediment dynamics of the region. Sea wall caused deprivation of sediment supply from the beach and induced beach lowering as indicated by continuing erosion in spite of the presence of the sea wall.

A Groin installed at Digha Mohona could induce high rate of accretion on the down drift par while significantly produced erosion on the up drift part at Shankarpur. Thus, the erosion and accretion of the shorelines in this region in a long run was observed to be caused more by the process of littoral drift than the effect of tide, wave and sea level rise. The long term trend of shoreline change was further applied to understand the future shoreline dynamics in the region, particularly in respect to the stability and sustainability of the tourism establishment of the Digha mandarmani Coast.

5.3. Future Prediction of Shoreline Movement

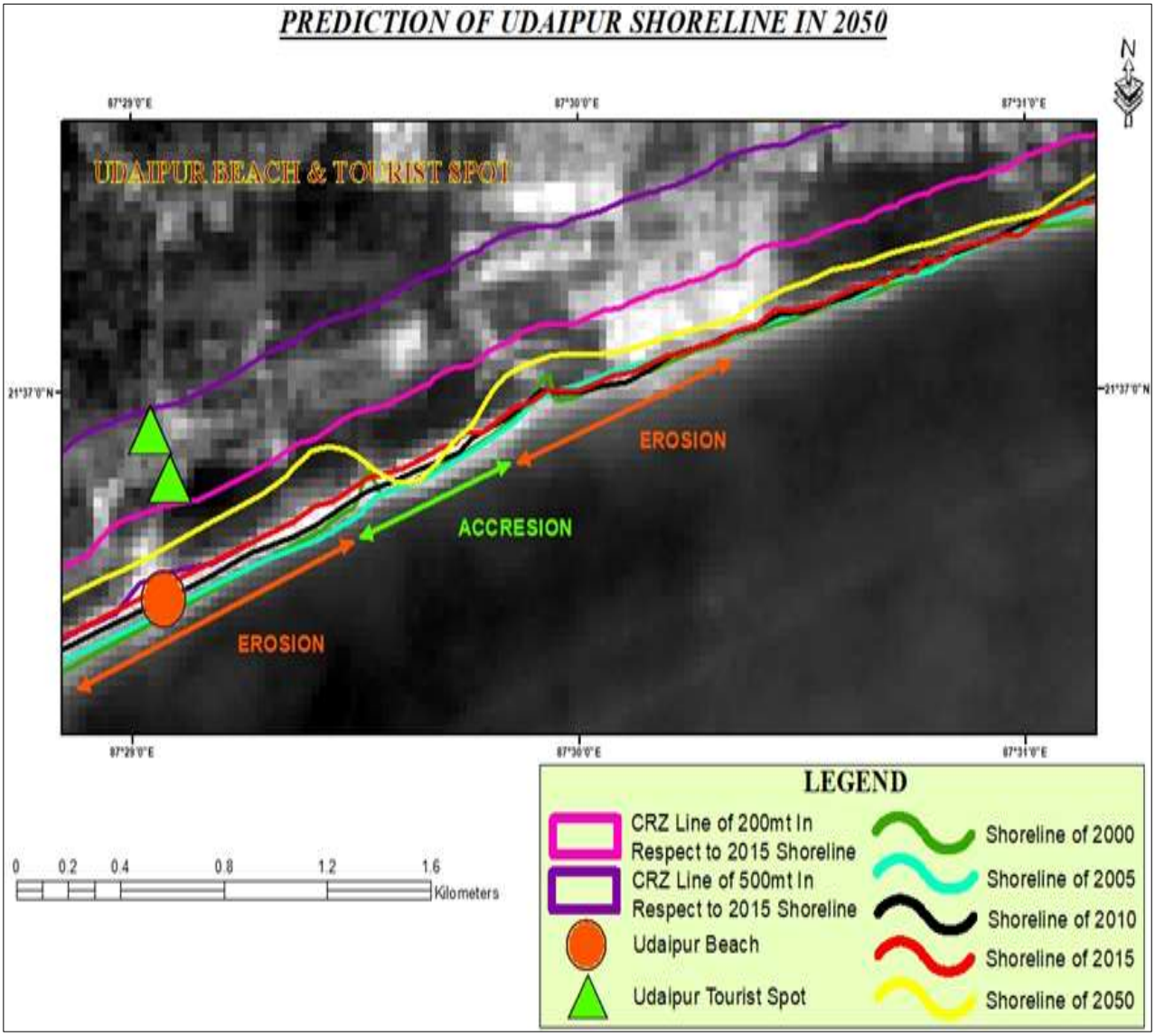

Fig 19: Showing Predicted Erosion & Accretion in Shoreline of 2050 and It's Effect on The Beach & Tourist Spot of Udaipur

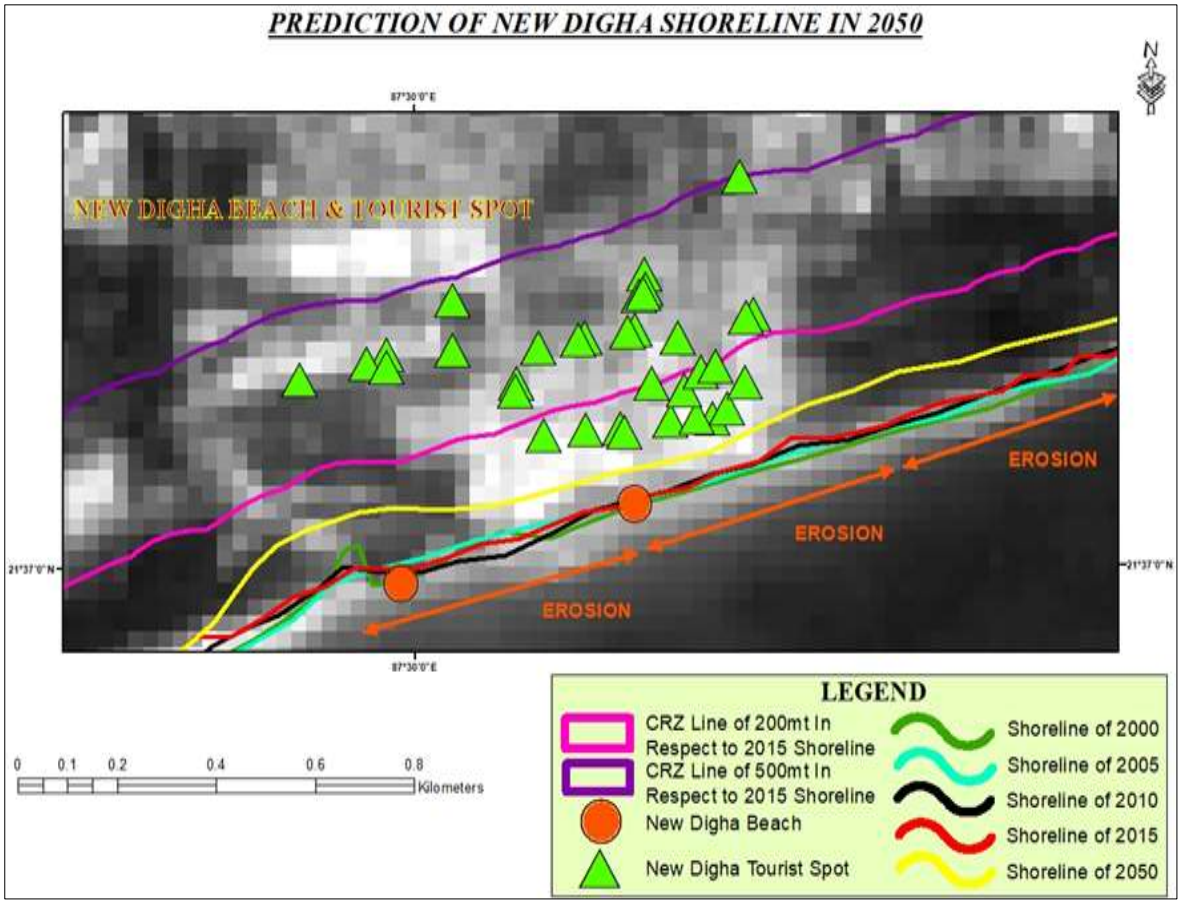

Fig 20: Showing Predicted Erosion & Accretion in Shoreline of 2050 and It's Effect on The Beach & Tourist Spot of New Digha

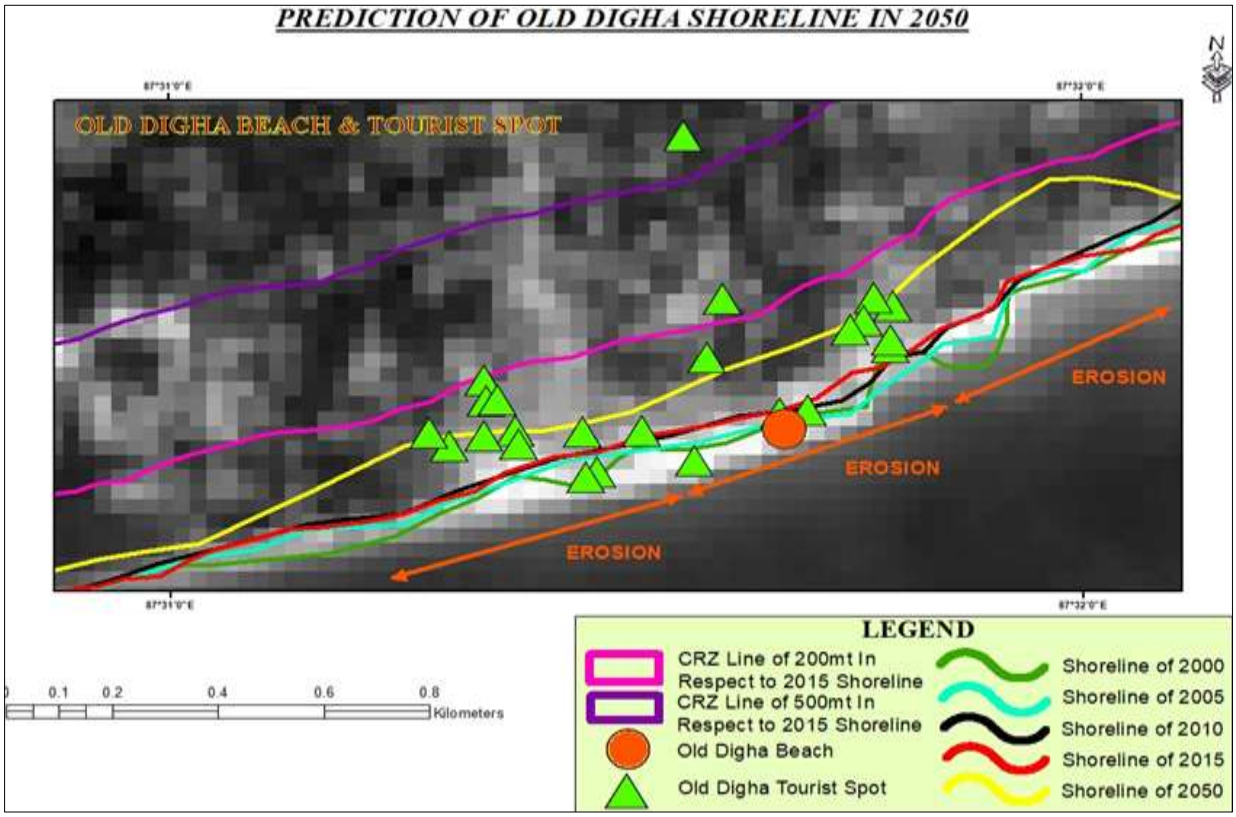

Fig 21: Showing Predicted Erosion & Accretion in Shoreline of 2050 and It's Effect on The Beach & Tourist Spot of Old Digh

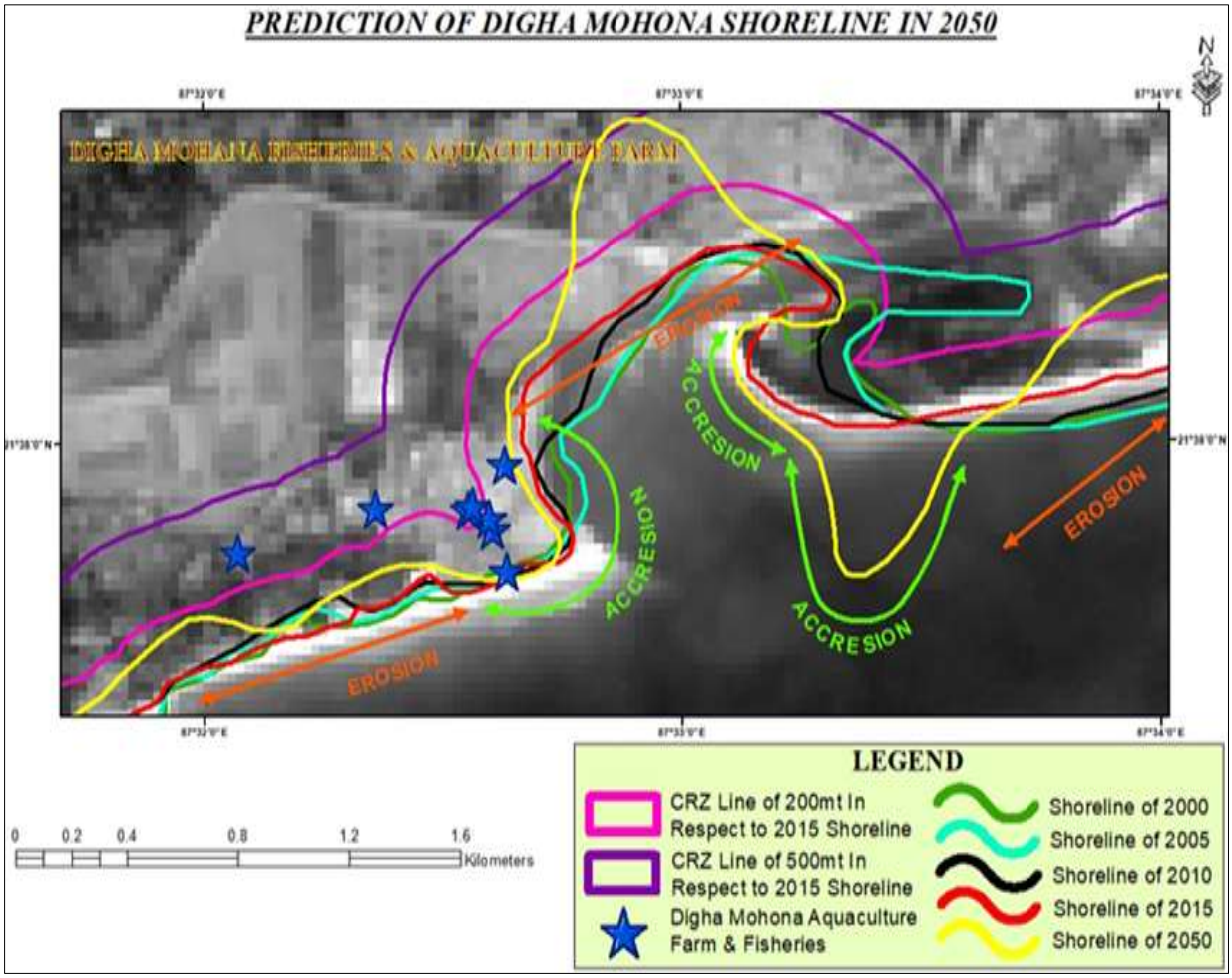

Fig 22: Showing Predicted Erosion & Accretion in Shoreline of 2050 and It's Effect on The Beach & Tourist Spot of Digha Mohona

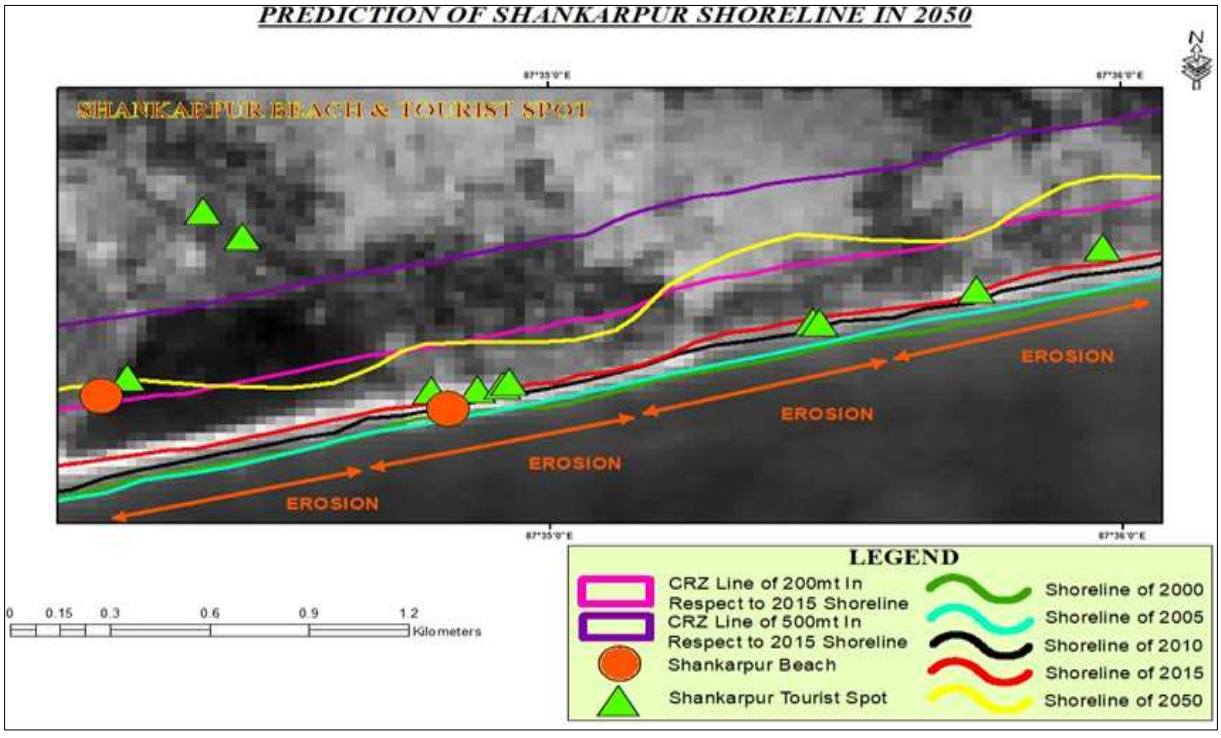

Fig 23: Showing Predicted Erosion & Accretion in Shoreline of 2050 and It's Effect on The Beach & Tourist Spot of Shankarpur

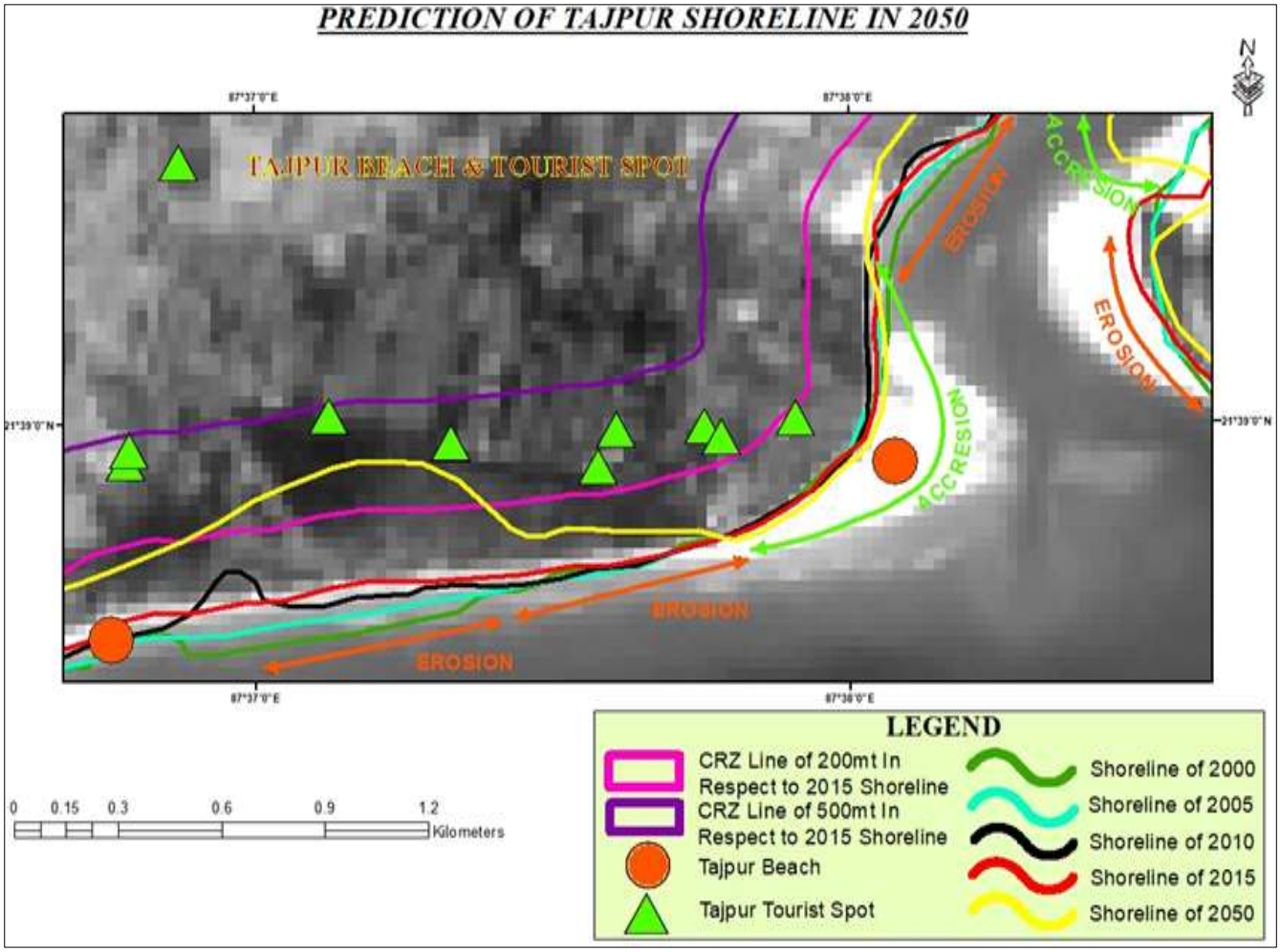

Fig 24: Showing Predicted Erosion & Accretion in Shoreline of 2050 and It's Effect on The Beach & Tourist Spot of Tajpur

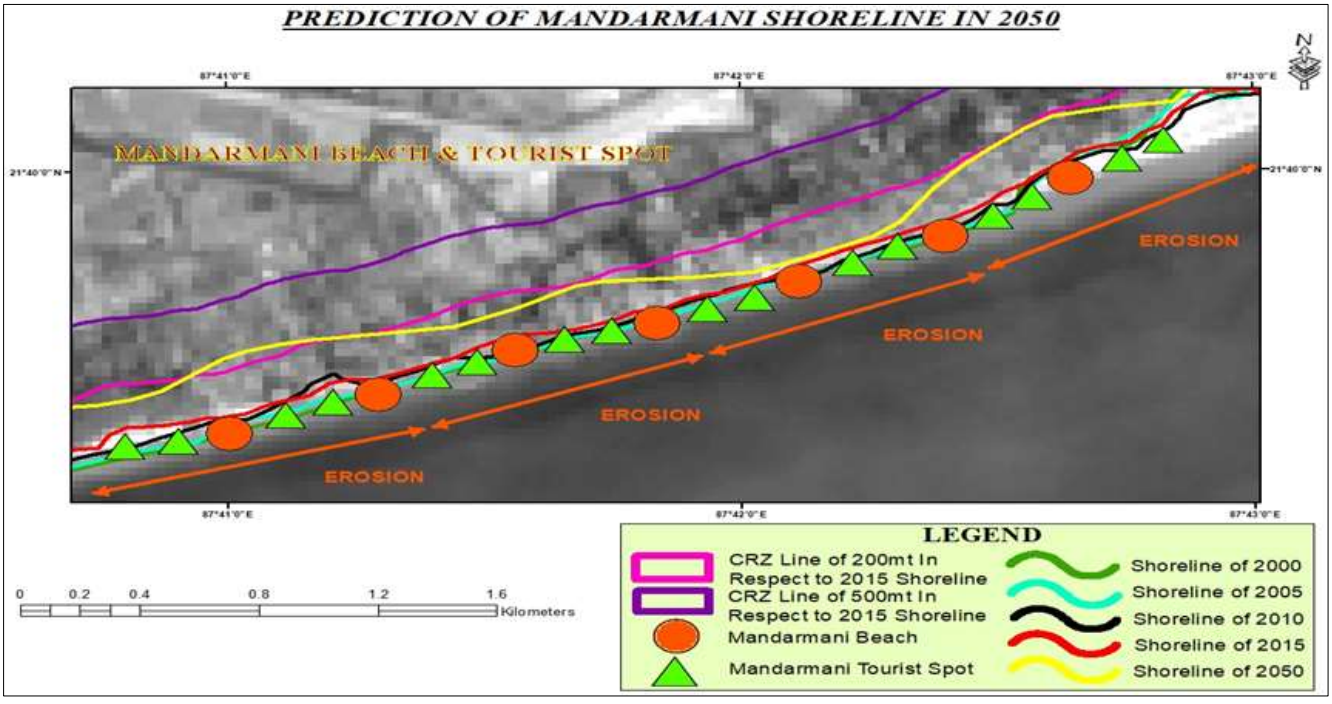

Fig 25: Showing Predicted Erosion & Accretion in Shoreline of 2050 and It's Effect on The Beach & Tourist Spot of Mandarmani

Using the Fishnet model, the shoreline of the study area has been assessed to decipher the trend of shoreline change along the preselected transacts around tourist establishments during the time period 2000-2015, and future (2050) position of shoreline was estimated (Plate 4-1 to Fig 4-7). In this estimation, shoreline change rate has been computed from historical observations, and short term impacts like tidal and storm surges were not considered. The future shoreline positions indicated that the maximum erosion will take place in the western bank of Digha Mohona while on the on the eastern bank it is to be maximum accretion. At the New & Old Digha erosion was observed to continue in future with variable rate, more along the unprotected part, but less along the segments protected by sea wall. Thus, the cumulative effect of various processes like sediment transport, littoral process, sea level rise are relevant to predict the future shoreline change.

According to the prediction for 2050 the majority of the tourist spot and beach of Udaipur, New Digha, Digha Mohona and Tajpur will remain mostly unaffected. But the beach and some areas including some hotels in Old Digha and Shankarpur would face significant negative consequences. The most severe impact would likely to be felt at the newly developed unprotected tourist resorts of Mandarmani where the beach and almost all the tourist establishments might be washed out by 2050 The net loss of coastal line during the period, was estimated to be 5789 meters. The predicted total Erosion and Accretion rate by 2050 along the selected transects from Udaipur to Mandarmani is given at the Table 2 below:

Table 2: Erosion and Accretion Prediction along the shoreline by 2050

Tourist Spots	Transect No	Shoreline Length	Estimated Shoreline Movement in 15 Yrs (2000-2015)		Predictedted Shoreline Movement in 35 Yrs (2015-2050)	
			Accretion (mts)	Erosion (mts)	Accretion (mts)	Erosion (mts)
Udaipur to Mandarmani	1 - 72	23 km	1134	3615	2645	8434

6. Conclusion

The main purpose of the study was to understand the behaviour of shoreline change (erosion and accretion) along the Digha-Mandarmani coast, the most favoured coastal tourism destination of West Bengal, by the application of Remote Sensing and GIS technique. The area covered seven tourist spots between Udaipur and Mandarmani. The study observed both the strongly retreating coast line with temporal and special variability with minor localised accretion between the time period of 2000 to 2015.The location Udaipur on the west of the coastal stretch closer to the Subarnarekha Estuary, an erstwhile accretionary beach started to experience brunt of coastal erosion 2010 onwards Erosion accretion pattern of New Digha and Old Digha area is found to be largely affected by the existence of protective sea wall which could restrict the erosion to some extent so that tourism establishments remained less affected. Implementation of a single groin near the Fish market on the Digha Mohona could initiate a significant sand accumulation upstream, while the downstream area of the groin like Shankarpur or Tajpur were found to be under accelerated erosion in absence of any protective structures. However, most alarming situation of coastal retreat was found along the beach of Mandarmani, the new yet unprotected coastal tourism destination of West Bengal The analysis revealed that only about 20% of the coastlines were under stable to accreting condition, while remaining 80% region experienced moderate to strong magnitude of coastal retreat. The Erosion Rate of 34mts/year in such areas highlights the alarming trend of the shoreline retreat which is of serious concern especially from the point of view of sustainability of tourism industry, particularly at Mandarmani. Also the urbanization due to tourism leads to immense pressure on this coastal area more than other coastal processes. Historic rates of shoreline change provided valuable input to the erosion process which helped to forecast of shoreline movement in future shoreline positions up to the year 2050. Five of the seven tourist locations along the coast under study may be non-existent unless some coastal protection measures are taken.

As human interventions are much more immense than anthropogenic impacts in this coastline that greatly influences the coastal processes, so the construction of unscientific infrastructure along the coast along with the cumulative action of waves and tides are responsible for the erosion/accretion trends. Where wave run-up is 2.16m and tidal range varies from 2.3m to 3m (Hazra, Sen and Bhandary, 2006, p. 2) [7]. On the other hand a large number of sea walls and breakwaters is influencing and altering the shoreline by disturbing the sediment dynamics of the region though this seawalls and groins were actually made for the protection of beach. More over this sea shore is also most sensitive to sea level change which has a rising trend in last 20 years. The MSL is rising 3 millimetre / year (ibid). Thus, the retreating and advancing activity of this region in the natural condition influenced mainly by the human interference along with combining effect of sea level fluctuation, sediment transport and coastal processes which are beyond ambit of present study.

Based on the present study, it can be concluded that accurate prediction and better understanding of shoreline movement can be done in a cost effective way using high resolution satellite data at smaller and longer intervals according to necessity and selecting short spaced transects for fishnet modelling accompanied with field survey. The accurate prediction and better understanding of shoreline movement will enable the decision makers to identify the present and future tourism zones at high risk and accordingly to appropriate suggest management measures. The present research of the shoreline movement might be helpful to devise a framework for the conservation and restorations of this coastline under severe sea erosion.

Reference

1. Anandabaskaran V, Vijayakumar G. 'Monitoring Shoreline Changes of the Puducherry Coast, South India: A Review and a Case Study', *International Journal for Research in Applied Science & Engineering Technology*. 2017; 5(11):2470-2477.
2. Baitalik A, Majumdar S. 'Coastal Tourism Destination in West Bengal: Historical Background and Development', *International Journal of Social Sciences and Management.* 2015; 2(3):267-272.

3. Chand P, Acharya P. 'Shoreline change and sea level rise along coast of Bhitarkanika wildlife sanctuary, Orissa: An analytical approach of remote sensing and statistical techniques', *International Journal of Geomatics and Geosciences*. 2010; 1(3):436-455.
4. Dwarakish GS, Vinay SA, Natesan U, Asano T. 'Coastal vulnerability assessment of the future sea level rise in Udupi coastal zone of Karnataka state, west coast of India', *International Journal Ocean & Coastal Management*. 2009; 52:467-478.
5. Das R. 'An Analytical Study on the Phytoresources and Vegetation Ecology of Coastal Medinipur of West Bengal in India', *International Journal of Science and Research*. 2012; 3(10):240-249.
6. Google Earth [Dated: 16/12/2019].
7. Hazra S, Sen GK, Bhandary G. Integrated Coastal Zone Management of Digha – Shankarpur Area, West Bengal. 1st edn. Kolkata: School of Oceanographic Studies, Jadavpur University, 2006.
8. https://en.wikipedia.org/wiki/Digha [Dated: 16/12/2019].
9. https://en.wikipedia.org/wiki/Mandarmani [Dated: 16/12/2019].
10. Joevivek V, Saravanan S, Chandrasekar N. 'Coastal Vulnerability and Shoreline Changes for Southern Tip of India – Remote Sensing and GIS approach', *The International Journal of Earth Science & Climatic Change*. 2013; 4(4):1-10.
11. Kankara RS, Selvan SC, Rajan B, Arockiaraj S. 'An adaptive approach to monitor the Shoreline changes in ICZM framework: A case study of Chennai coast', *Indian Journal of Geo-Marine Sciences*. 2014; 43(7):1266-1271.
12. Mukhopadhyay A, Mukherjee S, Mukherjee S, Ghosh, S. 'Automatic shoreline detection and future prediction: A case study on Puri Coast, Bay of Bengal', *India European Journal of Remote Sensing.* 2012; 45(1):201-213.
13. Misra A, Balaji R. 'A study on the shoreline changes and land-use / land-cover along the South Gujarat coastline', *International Journal of Procedia Engineering*. 2015; 116:381-389.
14. Mandal M, Dandapath PK, Bhushan S. 'Digha Shankarpur Littoral Tract A Geographical Case Study', *International Journal of Humanities and Social Science Invention.* 2013; 2(4):46-54.
15. Maiti S, Bhattacharya AK. 'Shoreline change analysis and its application to prediction: A remote sensing and statistics based approach', *International Journal of Marine Geology*. 2009; 257:11-23.
16. Nandi S, Ghosh M, Kundu A, Dutta D, Bakshi M. 'Shoreline shifting and its prediction using remote sensing and GIS techniques: a case study of Sagar Island, West Bengal (India)', October *Journal of Coastal Conservation*. 2015; 20:61-80.
17. Selvan SC, Kankara RS, Rajan B. 'Assessment of shoreline changes along Karnataka coast, India using GIS & Remote sensing techniques', I*ndian Journal of Marine Sciences*. 2014; 43(7):1-6.